CLAIMS

1. A recombinant microorganism that displays on its surface a binding moiety that, when administered to an animal, competes with a ligand for binding to a receptor for the ligand, wherein the binding moiety comprises an oligosaccharide which comprises a sugar residue that is attached to an acceptor moiety by a glycosyltransferase that is encoded by an exogenous nucleic acid which is present in the microorganism.

2. The recombinant microorganism of claim 1, wherein the microorganism is selected from the group consisting of bacteria, fungi, Mycoplasma, and yeast.

3. The recombinant microorganism of claim 1, wherein the oligosaccharide further comprises at least a second sugar residue that is attached to an acceptor moiety by at least a second glycosyltransferase.

4. The recombinant microorganism of claim 3, wherein the second glycosyltransferase is encoded by a second exogenous nucleic acid which is present in the microorganism.

5. The recombinant microorganism of claim 1, wherein the receptor is present on a surface of a cell.

6. The recombinant microorganism of claim 5, wherein the cell is an epithelial or endothelial cell that comprises a mucosal membrane of an animal.

7. The recombinant microorganism of claim 1, wherein the binding moiety is a mimic of a receptor for a toxin or adhesin of a pathogenic organism.

8. The recombinant microorganism of claim 7, wherein the toxin is an enterotoxin.

9. The recombinant microorganism of claim 7, wherein the toxin is selected from the group consisting of shiga toxins, clostridial toxins, cholera toxins, *E. coli* enterotoxins, and Staphylococcal enterotoxins.

10. The recombinant microorganism of claim 9, wherein the toxin is a shiga toxin.

11. The recombinant microorganism of claim 10, wherein the shiga toxin is selected from the group consisting of, Stx, Stx1, Stx2, Stx2c, Stx2d, and Stx2e.

12. The recombinant microorganism of claim 11, wherein the microorganism displays on it surface a mimic for all of the receptors in the group consisting of Stx1, Stx2, Stx2c and Stx2d.

13. The recombinant microorganism of claim 9, wherein the toxin is a clostridial toxin.

14. The recombinant microorganism of claim 13, wherein the clostridial toxin is selected from the group consisting of tetanus toxin, botulinum toxin, and *C. difficile* toxins A and B.

15. The recombinant microorganism of claim 9, wherein the toxin is selected from the group consisting of cholera toxin, *E. coli* heat labile enterotoxin types I and II, and ST toxins.

16. The recombinant microorganism of claim 7, wherein the binding moiety is a mimic of an adhesin receptor.

17. The recombinant microorganism of claim 16, wherein the adhesin is a CFA adhesin of an enterotoxigenic *E coli.*

18. The recombinant microorganism of claim 17, wherein the binding moiety is a mimic of a receptor for *E. coli* CS3 pili.

19. The recombinant microorganism of claim 17, wherein the binding moiety is a mimic of a receptor for K88ad fimbriae.

20. The recombinant microorganism of claim 16, wherein the binding moiety is a mimic of a receptor for an adhesin of *Entamoeba histolyticum.*

21. The recombinant microorganism of claim 16, wherein the binding moiety is a mimic of a receptor for an adhesin of a virus.

22. The recombinant microorganism of claim 21, wherein the virus is a rotavirus.

23. The recombinant microorganism of claim 22, wherein the rotavirus is a porcine rotavirus.

24. The recombinant microorganism of claim 1, wherein the binding moiety is a mimic of a receptor for a virus.

25. The recombinant microorganism of claim 1, wherein the binding moiety competes with a pathogenic organism for binding to a corresponding receptor on an animal epithelial or endothelial cell.

26. The recombinant microorganism of claim 25, wherein the oligosaccharide comprises a terminal sialic acid or galactose residue.

27. The recombinant microorganism of claim 26, wherein the pathogenic organism is selected from the group consisting of *Staphylococcus pneumonia, H. influenza, H. parainfluenza, Chlamydia trachomatis* and *Pseudomonas spp.*

28. The recombinant microorganism of claim 25, wherein the oligosaccharide comprises a terminal mannose residue and the pathogenic organism is *Acanthamoeba*.

29. The recombinant microorganism of claim 25, wherein the oligosaccharide comprises a terminal fucose residue.

30. The recombinant microorganism of claim 29, wherein the oligosaccharide comprises a Fucα1,2-Gal moiety and the pathogenic organism is *Candida albicans*.

31. The recombinant microorganism of claim 29, wherein the oligosaccharide comprises a 2'-Fuc or a 3'-Fuc linkage.

32. The recombinant microorganism of claim 31, wherein the pathogenic organism is *Helicobacter pylori*.

33. The recombinant microorganism of claim 1, wherein the binding moiety is a mimic of a receptor for a cell involved in inflammation.

34. The recombinant microorganism of claim 33, wherein the oligosaccharide comprises a 3'-sialoside or a 6'-sialoside.

35. The recombinant microorganism of claim 33, wherein the oligosaccharide comprises sialyl Lewis^x or sialyl Lewis^a.

36. The recombinant microorganism of claim 1, wherein the animal is selected from humans, pigs, cows, horses, canines, felines, chickens, turkeys, goats, rabbits, sheep, geese, ducks.

37. The recombinant microorganism of claim 1, wherein the binding moiety comprises an oligosaccharide selected from the group consisting of:

Galα[1→4]Galβ[1→4]Glc,

Galα[1→4]Galβ,

GalNAcβ[1→3]Galα[1→4]Galβ[1→4]Glc,

Galβ[1→4]GlcNAc,

Galα[1→3]Galβ[1→4]Glc,

Galα[1→3]Galβ[1→4]GlcNAc,

Galβ[1→4]GlcNAcβ[1→3]Galβ[1→4]Glc,

Glcα[1→6]Glc,

Glcα[1→6]Glcα[1→6]Glc,

NeuNAc,

Galβ[1→3]GalNAcβ[1→4]Galβ[1→4]Glc,
|
NeuNAcα[2→3]

Galβ[1→3]GalNAcβ[1→4]Galβ[1→4]Glc,

GalNAcβ[1→4]Gal,

GalNAc,

Gal,

NeuGc→GM_3, and

NeuNAc→GM_3.

38. The recombinant microorganism of claim 37, wherein the binding moiety comprises Galα[1→4]Galβ[1→4]Glc.

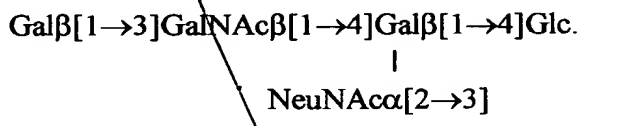
39. The recombinant microorganism of claim 37, wherein the binding moiety comprises GalNAcβ[1→3]Galα[1→4]Galβ[1→4]Glc.

40. The recombinant microorganism of claim 37, wherein the binding moiety comprises an oligosaccharide selected from the group consisting of: Galβ[1→4]GlcNAc, Galβ[1→4]GalNAcβ[1→3]Galβ[1→4]Glc, Galα[1→3]Galβ[1→4]GalNAc and Galα[1→3]Galβ[1→4]Glc.

41. The recombinant microorganism of claim 37, wherein the binding moiety comprises NeuNAc.

42. The recombinant microorganism of claim 37, wherein the binding moiety comprises an oligosaccharide selected from the group consisting of Glcα[1→6]Glc and Glcα[1→6]Glcα[1→6]Glc.

43. The recombinant microorganism of claim 37, wherein the binding moiety comprises the oligosaccharide:



44. The recombinant microorganism of claim 37, wherein the binding moiety comprises an oligosaccharide selected from the group consisting of NeuGc→GM_3 and NeuNAc→GM_3.

45. The recombinant microorganism of claim 1, wherein the binding moiety is a mimic of natural receptor for adhesins or toxins produced by a micro-organism selected from a group of genera consisting of *Escherichia, Salmonella, Shigella, Citrobacter, Helicobacter, Yersinia, Vibrio, Aeromonas, Campylobacter, Pseudomonas, Pasteurella, Neisseria, Haemophilus, Klebsiella, Staphylococcus, Streptococcus, Clostridium*, rotavirus, and *Entamoeba*.

46. The recombinant microorganism of claim 1, wherein the microorganism further comprises one or more exogenous enzymes involved in synthesis of a nucleotide sugar which serves as a donor for the glycosyltransferase.

47. The recombinant microorganism of claim 46, wherein the nucleotide sugar is selected from the group consisting of GDP-Man, UDP-Glc, UDP-Gal, UDP-GlcNAc, UDP-GalNAc, CMP-sialic acid, GDP-Fuc, and UDP-xylose.

48. The recombinant microorganism of claim 46, wherein the enzyme is a nucleotide sugar synthetase.

49. The recombinant microorganism of claim 46, wherein the enzyme is involved in synthesis of a nucleotide that comprises the nucleotide sugar.

50. The recombinant microorganism of claim 46, wherein the enzyme is involved in synthesis of a sugar that comprises the nucleotide sugar.

51. The recombinant microorganism of claim 46, wherein the one or more sugars transferred to the acceptor molecule by the exogenous glycosyltransferases make up the entirety of the receptor mimic.

52. The recombinant microorganism as in claim 1, wherein a combination of sugars of the acceptor molecule and the one or more sugars transferred to the acceptor molecule by the exogenous transferases make up the entirety of the receptor mimic.

53. The recombinant microorganism as in claim 1, wherein the completed acceptor molecule has a terminal residue to which the exogenous glycosyltransferases transfer sugars to make up the receptor mimic.

54. The recombinant microorganism as in claim 1, wherein the acceptor molecule is an incomplete endogenous molecule and at least one of the exogenous glycosyltransferases competes with an endogenous glycosyltransferase to transfer said sugar molecule thereto.

55. The recombinant microorganism as in claim 1, wherein the binding moiety is anchored to the outer surface of the microorganism.

56. The recombinant microorganism as in claim 55, wherein the microorganism is gram negative and the acceptor molecule is a lipopolysaccharide.

57. The recombinant microorganism as in claim 56, wherein the acceptor molecule is all or a portion of the core of the lipopolysaccharide.

58. The recombinant microorganism as in claim 1, wherein said microorganism is selected from a genus selected from the group consisting of *Escherichia, Salmonella, Acidophilus, Lactobacillus, Lactococcus* and *Bifidobacterium*.

59. The recombinant microorganism as in claim 58, wherein said microorganism is selected from a species selected from the group consisting of *Escherichia coli* and *Salmonella enterica* sv typhimurium.

60. The recombinant microorganism as in claim 1, wherein the microorganism is chosen by reason of having reduced production of external masking polysaccharide molecules other than said acceptor molecule to enhance exposure of the receptor mimic.

61. The recombinant microorganism as in claim 60, wherein the microorganism has reduced production of external molecules selected from the group comprising a slime layer, capsule or exopolysaccharide.

62. The recombinant microorganism as in claim 1, wherein the microorganism is selected to provide some resistance to antimicrobial activity of microflora potentially resident in the gut.

63. The recombinant microorganism as in claim 1, wherein the microorganism is resistant to the major families of colicins.

64. The recombinant microorganism as in claim 1, wherein all or some of the one or more glycosyl transferases are naturally occurring.

65. The recombinant microorganism as in claim 1, wherein genes encoding all or some of the one or more glycosyl transferases are modified to stabilise phase variation.

66. A recombinant microorganism expressing one or more exogenous sugar transferases, or one or more exogenous nucleotide sugar precursor synthesising enzymes, said

microorganism also expressing an acceptor molecule, said one or more exogenous sugar transferases being specific for the transfer of one or more sugar residues represented progressively from a non reducing terminal end of a receptor of either a toxin or an adhesin of a pathogenic organism, the exogenous sugar transferases progressively transferring said one or more sugar resides onto the acceptor molecule to thereby form a chimeric carbohydrate molecule with an exposed receptor mimic, said sugar precursor enzymes forming nucleotide precursors that are transferred to said acceptor molecule to make up said chimeric carbohydrate, said exposed receptor mimic capable of binding the toxin or the adhesin.

67. A pharmaceutical preparation for administration to a mucosal surface, said preparation including a delivery microorganism or a partially or fully purified non-toxic preparation of a carbohydrate molecule therefrom, at least a part of said carbohydrate molecule acting as an exposed receptor mimic, said receptor mimic capable of binding a toxin or an adhesin of a pathogen that normally binds to said mucosal surface, said pharmaceutical preparation being carried in a pharmaceutically acceptable excipient.

68. The pharmaceutical preparation as in claim 67, wherein the delivery microorganism is a recombinant microorganism expressing one or more exogenous sugar transferases and an acceptor molecule, said one or more exogenous sugar transferases being specific for transfer of one or more sugar residues represented progressively from a non reducing terminal end of a receptor of either a toxin or an adhesin of a pathogenic organism, said delivery microorganism expressing an acceptor molecule, and progressively transferring said one or more sugar resides onto the acceptor molecule to thereby form the chimeric carbohydrate molecule with the receptor mimic, said exposed receptor mimic capable of binding the toxin or the adhesin.

69. The pharmaceutical preparation as in claim 67, wherein the receptor mimic is a mimic of the receptor of a toxin.

70. The pharmaceutical preparation as in claim 69, wherein the toxin is selected from the group consisting of shiga toxins, clostridial toxins, cholera toxins, *E. coli* enterotoxins, and Staphylococcal enterotoxins.

71. The pharmaceutical preparation as in claim 70, wherein the toxin is a shiga toxin.

72. The pharmaceutical preparation as in claim 70, wherein the toxin is a clostridial toxin.

73. The pharmaceutical preparation as in claim 67, wherein the receptor mimic is partially or wholly formed within a sugar moiety of selected from the group comprising:

Galα[1→4]Galβ[1→4]Glc,

Galα[1→4]Galβ,

GalNAcβ[1→3]Galα[1→4]Galβ[1→4]Glc,

Galβ[1→4]GlcNAc,

Galα[1→3]Galβ[1→4]Glc,

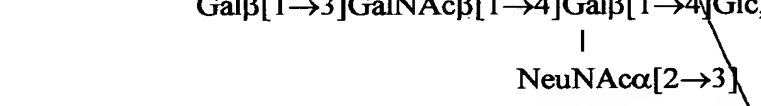
Galα[1→3]Galβ[1→4]GlcNAc,

Galβ[1→4]GlcNAcβ[1→3]Galβ[1→4]Glc,

Glcα[1→6]Glc,

Glcα[1→6]Glcα[1→6]Glc,

NeuNAc,



Galβ[1→3]GalNAcβ[1→4]Galβ[1→4]Glc,
|
NeuNAcα[2→3]

Galβ[1→3]GalNAcβ[1→4]Galβ[1→4]Glc,

GalNAcβ[1→4]Gal,

GalNAc,

Gal,

NeuGc→GM_3, and

NeuNAc→GM_3.

74. The pharmaceutical preparation as in claim 67, wherein one or more exogenous nucleotide sugar precursor synthesising enzymes are also expressed by said

organism, said sugar precursor enzymes forming precursors to make up said chimeric carbohydrate.

75. The pharmaceutical preparation as in claim 67, wherein genes encoding the all or some of the one or more glycosyl transferases are modified to prevent phase variation.

76. The pharmaceutical preparation as in claim 67, wherein the delivery microorganism is non harmful and live.

77. The pharmaceutical preparation as in claim 67, wherein the delivery microorganism is protected by a protective capsule or held within a protective matrix.

78. The pharmaceutical preparation as in claim 67, wherein the target mucosal surface is gastrointestinal.

79. The pharmaceutical preparation as in claim 78, wherein the delivery microorganism is selected to provide some resistance to antimicrobial activity of microflora potentially resident in the gut.

80. The pharmaceutical preparation as in claim 79, wherein the delivery microorganism is resistant to the major families of colicins.

81. The pharmaceutical preparation as in claim 79, wherein the delivery microorganism is grown under conditions to induce acid tolerance.

82. The pharmaceutical preparation as in claim 78, wherein the delivery microorganism is enteric.

83. The pharmaceutical preparation as in claim 82, wherein the delivery microorganism belongs to an enteric genera selected from the group consisting of *Escherichia, Salmonella, Acidophilus, Lactobacillus, Lactococcus, Streptococcus* and *Bifidobacterium*.

84. The pharmaceutical preparation as in claim 67, wherein the delivery microorganism is killed.

85. The pharmaceutical preparation as in claim 84, wherein the delivery microorganism is killed by treatment with a chemical agent selected from the group consisting of formalin or thiomersal, or by treatment with a bactericidal antibiotic, or by exposure to heat or UV irradiation.

86. The pharmaceutical preparation as in claim 67, wherein the carbohydrate molecule is lipopolysaccharide and the carbohydrate is delivered as an intact or partially intact membrane preparation selected from the group consisting of bacterial ghosts, liposomes incorporating chimeric lipopolysaccharide or membrane vesicles.

87. The pharmaceutical preparation as in claim 67, wherein the carbohydrate is the carbohydrate portion of lipopolysaccharide, and the preparation includes purified or semipurified lipopolysaccharide.

88. A method of administering a receptor mimic to a mucosal surface of a mammal, the method comprising the administration of a quantity of a delivery microorganism, or parts thereof, the delivery microorganism exhibiting one or more sugars in a configuration to form an exposed receptor mimic, the receptor mimic being a mimic of a receptor of a pathogen, said quantity being sufficient to reduce adherence of the pathogen or a toxin produced by the pathogen to the mucosal surface.

89. The method of administering a receptor mimic as in claim 88, wherein the delivery microorganism is a recombinant microorganism expressing one or more exogenous sugar transferases and an acceptor molecule, said one or more exogenous sugar transferases being specific for transfer of one or more sugar residues represented progressively from a non reducing terminal end of a receptor of either a toxin or an adhesin of a pathogenic organism, the exogenous sugar transferases progressively transferring said one or more sugar resides onto the acceptor molecule to thereby form a chimeric carbohydrate

molecule with the exposed receptor mimic being exposed, said exposed receptor mimic capable of binding the toxin or the adhesin.

90. The method of administering a receptor mimic as in claim 88, wherein the receptor mimic is a mimic of the receptor of a toxin.

91. The method of administering a receptor mimic as in claim 90, wherein the toxin is selected from the group consisting of shiga toxins, clostridial toxins, cholera toxins, *E. coli* enterotoxins, and staphylococcal enterotoxins.

92. The method of administering a receptor mimic as in claim 91, wherein the toxin is a shiga toxin.

93. The method of administering a receptor mimic as in claim 91, wherein the toxin is a clostridial toxin.

94. The method of administering a receptor mimic as in claim 88, wherein the receptor mimic is partially or wholly formed within a sugar moiety of selected from the group comprising:

Galα[1→4]Galβ[1→4]Glc,

Galα[1→4]Galβ,

GalNAcβ[1→3]Galα[1→4]Galβ[1→4]Glc,

Galβ[1→4]GlcNAc,

Galα[1→3]Galβ[1→4]Glc,

Galα[1→3]Galβ[1→4]GlcNAc,

Galβ[1→4]GlcNAcβ[1→3]Galβ[1→4]Glc,

Glcα[1→6]Glc,

Glcα[1→6]Glcα[1→6]Glc,

NeuNAc,

Galβ[1→3]GalNAcβ[1→4]Galβ[1→4]Glc,
|
NeuNAcα[2→3]

Galβ[1→3]GalNAcβ[1→4]Galβ[1→4]Glc,

GalNAcβ[1→4]Gal,

GalNAc,

Gal,

NeuGc→GM_3, and

NeuNAc→GM_3.

95. The method of administering a receptor mimic as in claim 88, wherein the receptor mimic of the purified carbohydrate is partially or wholly formed within a sugar moiety selected from the group comprising

Galα[1→4]Galβ[1→4]Glc,

GalNAcβ[1→3]Galα[1→4]Galβ[1→4]Glc, and

Galβ[1→3]GalNAcβ[1→4]Galβ[1→4]Glc.

96. The method of administering a receptor mimic as in claim 95, wherein genes encoding the all or some of the one or more glycosyl transferases are modified to stabilise phase variation.

97. The method of administering a receptor mimic as in claim 88, wherein one or more exogenous nucleotide sugar precursor synthesising enzymes are also expressed by said organism, said sugar precursor enzymes forming precursors to make up said chimeric carbohydrate.

98. The method of administering a receptor mimic as in claim 88, wherein the delivery microorganism is non harmful and live.

99. The method of administering a receptor mimic as in claim 88, wherein the administration is enterally.

100. The method of administering a receptor mimic as in claim 99, wherein the delivery microorganism is protected by a protective capsule or held within a protective matrix.

101. The method of administering a receptor mimic as in claim 99, wherein the delivery microorganism is selected to provide some resistance to antimicrobial activity of microflora potentially resident in the gut.

102. The method of administering a receptor mimic as in claim 99, wherein the delivery microorganism is resistant to the major families of colicins.

103. The method of administering a receptor mimic as in claim 99, wherein the delivery microorganism is grown under conditions to induce acid tolerance.

104. The method of administering a receptor mimic as in claim 99, wherein the delivery microorganism is enteric.

105. The method of administering a receptor mimic as in claim 104, wherein the delivery microorganism is belongs to an enteric genera selected from the group consisting of Escherichia, Salmonella, Acidophilus, Lactobacillus, Lactococcus and Bifidobacterium.

106. The method of administering a receptor mimic as in claim 88, wherein the delivery microorganism is killed.

107. The method of administering a receptor mimic as in claim 106, wherein the delivery microorganism is killed by treatment with a chemical agent selected from the group consisting of formalin, or thiomersal, or a bactericidal antibiotic, or by exposure to heat or to UV irradiation.

108. The method of administering a receptor mimic as in claim 88, wherein the carbohydrate molecule is lipopolysaccharide and the carbohydrate is delivered as an intact or partially intact membrane preparation selected from the group consisting of bacterial ghosts, liposomes incorporating chimeric lipopolysaccharide or membrane vesicles.

109. The method of administering a receptor mimic as in claim 88, wherein the carbohydrate is the carbohydrate portion of lipopolysaccharide and the preparation includes purified or semipurified lipopolysaccharide.

110. The method of administering a receptor mimic as in claim 88, wherein the receptor mimic is that of a porcine rotavirus or shiga like toxin active in pigs, including the step of adding the delivery microorganism to pig feed or drink.

111. A purified chimeric carbohydrate purified from the recombinant organism of claim 1.

112. A method of testing for the presence of a toxin or a pathogenic microorganism in a sample, the method comprising:

contacting a sample with the purified carbohydrate of claim 89, either the purified carbohydrate or the sample being immobilized;

washing off unbound purified carbohydrate or toxin or pathogenic microorganism; and

adding detection means to detect bound purified carbohydrate and the toxin or pathogenic microorganism.

113. The method of testing as in claim 112, wherein the purified carbohydrate is immobilised on a support.

114. The method of testing as in claim 113, wherein the purified carbohydrate is lipopolysaccharide.

115. The method of testing as in claim 112, wherein the receptor mimic of the purified carbohydrate is partially or wholly formed within a sugar moiety selected from the group comprising

Galα[1→4]Galβ[1→4]Glc,

Galα[1→4]Galβ,

GalNAcβ[1→3]Galα[1→4]Galβ[1→4]Glc,

Galβ[1→4]GlcNAc,

Galα[1→3]Galβ[1→4]Glc,

Galα[1→3]Galβ[1→4]GlcNAc,

Galβ[1→4]GlcNAcβ[1→3]Galβ[1→4]Glc,

Glcα[1→6]Glc,

Glcα[1→6]Glcα[1→6]Glc,

NeuNAc,

Galβ[1→3]GalNAcβ[1→4]Galβ[1→4]Glc,
|
NeuNAcα[2→3]

Galβ[1→3]GalNAcβ[1→4]Galβ[1→4]Glc,

GalNAcβ[1→4]Gal,

GalNAc,

Gal,

NeuGc→GM_3, and

NeuNAc→GM_3.

116. The method of testing as in claim 115, wherein the receptor mimic of the purified carbohydrate is partially or wholly formed within a sugar moiety selected from the group comprising

Galα[1→4]Galβ[1→4]Glc,

GalNAcβ[1→3]Galα[1→4]Galβ[1→4]Glc; and

Galβ[1→3]GalNAcβ[1→4]Galβ[1→4]Glc.